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THERMAL CONDUCTIVITY OF UNIBESTOS PIPE INSULATION

Manufactured by
Union Asbestos and Rubber Company
Bloomington, Illinois

by

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and
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to

Bureau of Yards and Docks
Office of the Chief of Engineers
Headquarters, U.S. Air Force
Washington, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE

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Introduction

As a part of the Tri-Service studies of insulation for underground heat distribution systems, three separate tests were made of the thermal conductivity of Unibestos Pipe Insulation manufactured by the Union Asbestos and Rubber Co., Bloomington, Illinois. The several tests were made to investigate the variability of the material between specimens, the variability of the thermal conductivity from the interior to the exterior surface of a given specimen, and the temperature coefficient of the thermal conductivity.

Materials

The specimens for the tests were cut from 2 lengths of Unibestos Pipe Insulation obtained from the manufacturer and identified as follows:

Sample A - Unibestos pipe insulation, 4 in. i.d., 10 in. o.d., 36 in. long.

Sample B - Unibestos pipe insulation, 8 in. i.d., 18 in. o.d., 36 in. long. The shipping carton was marked: "No. 1200 Unibestos Pipe Insulation, Grade 3, Class F, 3 ft, Pipe Size 8, Thickness 5, Navy, Carton 121 Code No. 9906112-675." The overall dry density of a half section of this sample was 15.0 lb/ft^3.

Specimens

Flat specimens with dimensions of 8 x 8 inches and about 1-inch thickness were cut from the samples for the three series of tests. The original location of the specimens in the cylindrical samples are further described as follows:

Series 1 - The two pieces were cut with one face substantially tangent to the inside surface of Sample A.

Series 2 - The two pieces were cut with one face substantially tangent to the cylindrical surface of radius one inch greater than the inside radius of Sample B. This pair of specimens is identified as B-O in Table 1.

Series 3 - The attached photograph shows the juxtaposition of the pairs cut from Sample B to yield three pairs of 8-inch square test specimens, numbered 1, 2, and 3 in outward progression from the center of the sample. The inner surface of Specimen 1 was 3/16 in. from the inner surface of the sample; the successive specimens were contiguous, but separated by the 0.06-in. width of the sawcut. The specimens numbered 1, 2, and 3 in the photograph are identified as B-1, B-2, and B-3, respectively, in Table 1.

Procedure

The thermal conductivity of the specimens was measured in an 8-inch guarded hot-plate apparatus conforming with the requirements of Fed. Spec. LLL-F-321b and of ASTM C177-45. The specimens were air-dried to constant weight in an oven at 215°F immediately prior to the conductivity measurements. The pair of specimens taken from Sample A was tested at mean temperatures of about 74°F and 129°F, whereas the specimens taken from Sample B for Test Series 2 and 3 were tested only at the higher mean temperature.

Test Results and Discussion

The results obtained during the 3 series of tests are summarized in Table 1. The values of thermal conductivity at two mean temperatures for Specimen A indicate that the temperature coefficient of conductivity a_T, defined by the equation $k_t = k_T(1 + a_T(t - T))$, is 0.00066 at T = 129°F, for this specimen.

It will be noted in Table 1 that the density, as tested, of the five different insulation specimens, A, B-0, B-1, B-2, and B-3, ranged from 10.9 to 16.3 lb/ft^3, a variation of 42 percent of the mean value for the five specimens. The density of Specimen A, one face of which was tangent to the inside surface of the cylindrical Sample A, was the highest; and the density of Specimen B-1 was next to the highest. One surface of Specimen B-1 was tangent to a circle with a radius only 3/16-inch greater than that of the inner surface of the cylindrical sample. The increase in density near the inner surface was believed to be caused by a greater concentration of silicate in this zone resulting from the method of manufacture.

In the five tests made at a mean temperature of about 129°F, the thermal conductivity values, as shown in Table 1, ranged from 0.323 to 0.408 $Btu/hr(ft)^2(deg\ F/inch)$, a maximum variation of about 24 percent

of the mean value for the five tests. The thermal conductivities of the five different specimens were not directly proportional to their density. If the five values obtained at the same mean temperature in tests 1, 3, 4, 5, and 6 are corrected to a common density of 15 lb/ft^3 by direct proportion, the maximum variation in the resulting computed thermal conductivities is about 29 percent of the mean of the five values.

It should be noted that the densities of Specimens B-1, B-2, and B-3 were all appreciably below the average dry density of 15.0 lb/ft^3 observed for the half-cylinder from which they were taken. This indicates that the material in the half-cylinder, not represented by the three pairs of specimens, was considerably more dense than the portions comprising the samples, even though the specimens represented a major part of the cross section of the half-cylinder.

The variability in thermal conductivity revealed by these test results indicate that a method for measuring the average thermal conductivity of a complete cylindrical section of insulation might be preferable for materials of this type even though the fit of the specimen on the test cylinder introduces a problem in such an apparatus.

Table 1

Thermal Conductivity of Several Specimens of Unibestos Pipe Insulation

Test Series	1		2	3		
Test Number	1	2	3	4	5	6
Specimen Identification	A	A	B-0	B-1	B-2	B-3
Density, as tested, lb/ft^3	16.3[a]	16.2[a]	11.6[b]	13.5	10.9	11.8
Thickness, as tested, inch	1.14	1.14	1.09	1.05_4	1.06_1	1.06_3
Thermal conductivity, Btu/hr ft^2(deg F/inch)	0.381	0.367	0.336	0.408	0.345	0.323
Mean temperature of specimens, °F	129.2	73.7	129.0	128.3	128.3	129.9
Temp. gradient in specimens, deg F/inch	36.4	38.3	37.9	38.0	38.3	37.9
Loss of weight on drying, percent	3.0	--	1.9	3.5	3.1	3.2
Gain in weight during test, percent	1.0	0.4	0.7	0.8	0.8	0.7

a - The central 4-in. squares of the 8-in. specimens, which constituted the area through which the conductivity measurement was made, had an average density of 16.1 lb/ft^3.

b - The average density of one of the halves of Sample B was measured as 15.3 lb/ft^3 undried, corresponding to about 15.0 lb/ft^3 in an oven-dried condition.

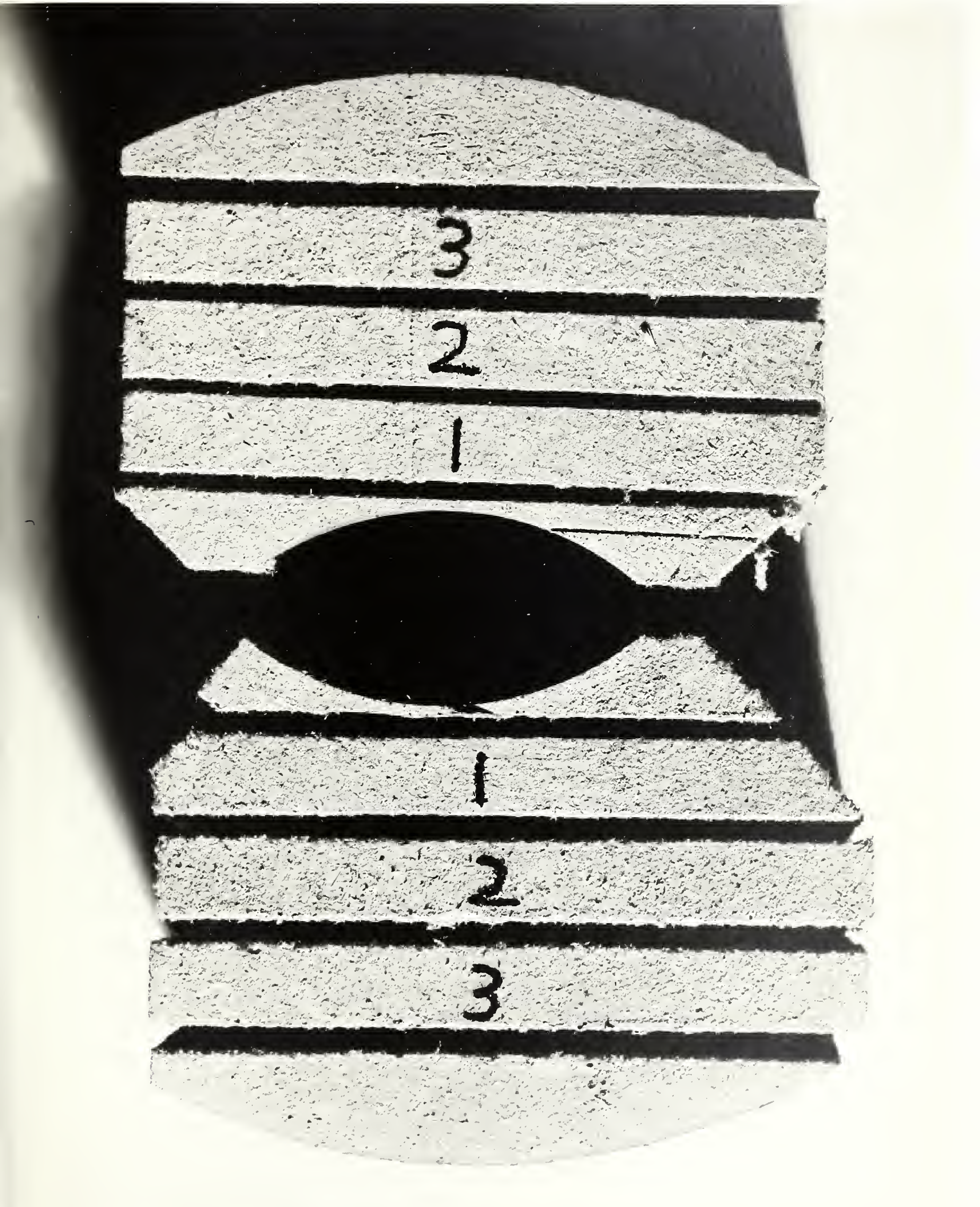

Figure 1